

Radiologic Diagnosis in Abdominal Trauma

J. H. WOODRUFF, JR., M.D., and J. H. SIMONTON, M.D., Torrance

TWO HUNDRED AND SEVENTEEN patients with abdominal and retroperitoneal trauma, proved at operation or autopsy, have been seen in the operating rooms of the Los Angeles County Harbor General Hospital during the past 12 years. Both penetrating and nonpenetrating trauma were included, surgical trauma excluded.

In many cases roentgenographic examination was helpful in diagnosis, and serial studies gave additional evidence at times. In some cases no abnormalities were seen in x-ray films although serious injury was present. Almost one fourth of the patients had more than one injury. At times the more serious hidden injury was overlooked because of preoccupation with lesser more obvious trauma. The necessary measures to stop hemorrhage, combat shock, and deal with similar emergencies were given precedence, but radiologic examination was carried out in 198 patients, usually soon after admission. The radiologic examination varied with the kind of injury and the kind of lesion suspected. The correlation of clinical and radiologic examination was essential. Sometimes the radiographic examination was done without moving the patient from the stretcher.

Exposures as short as 1/20 second were employed. A fine line stationary grid or a recipromatic wall-mounted Bucky grid was used to "clean up" secondary radiation. It was not necessary to exceed potentials of 100 kilovolt peak. The milliamperage varied from 20 with mobile equipment to 300 with stationary.

A skillful experienced technician was a necessity for the efficient safe handling of patients with abdominal trauma. Specialized equipment was useless without such a technician.

The radiologist was consulted before, during and after a number of these examinations. It would have been better had he been consulted in all.

Table 1 shows the incidence by sites of lesions. The relatively low incidence of renal injuries is explained by the fact that the series here reported is made up of those proven at operation or autopsy,

From the Departments of Radiology of the Los Angeles County Harbor General Hospital, Torrance, and the University of California, Los Angeles 24.

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• In a survey of its use in 198 cases of penetrating and nonpenetrating abdominal trauma causing various kinds of lesions, roentgenographic examination was found to be a considerable diagnostic aid. Consultation with a radiologist before, during and after the examination would seem indicated.

The general plan of examination included anteroposterior projections with the patient erect, recumbent and in the left lateral decubitus positions, plus a posteroanterior film of the chest with the patient erect. Techniques varied with the condition of the patient and the nature of the lesion clinically suspected. Special procedures were done as dictated by the clinical and radiologic findings. Studies designed to demonstrate displacement of gastrointestinal and urinary organs should be made in anteroposterior and lateral projections.

Factors that were important in determining the site of internal lesions from radiographic evidence were the site of associated fractures, reactive ileus, the position of foreign bodies, and by far the most important the roentgen abnormalities caused by escaped gas, blood, other fluids or contrast media, which caused abnormal densities, displacements of organs and blurring or obliteration of outlines normally visible.

TABLE 1.—Incidence of Penetrating and Nonpenetrating Trauma

| Site | Nonpenetrating | Penetrating | Total |
|---------------------------|----------------|-------------|-------|
| Spleen | 49 | 7 | 56 |
| Abdominal wall | 2 | 46 | 48 |
| Small intestine | 8 | 26 | 34 |
| Liver | 14 | 14 | 28 |
| Bladder | 20 | 2 | 22 |
| Kidney | 12 | 7 | 19 |
| Colon | 2 | 15 | 17 |
| Stomach | 1 | 15 | 16 |
| Diaphragm | 4 | 11 | 15 |
| Pancreas | 3 | 5 | 8 |
| Vascular structures | 3 | 4 | 7 |
| Gallbladder | 0 | 2 | 2 |
| | 120 | 152 | 272 |

whereas renal injuries were the most frequently diagnosed clinically.

Types of Trauma

Trauma was divided into two types, that which penetrates the abdominal wall, and that which does not. Stab wounds and gunshot wounds were the usual penetrating ones, and nonpenetrating trauma

included that received in motor vehicle accidents, falls, blows to the abdomen, and the like. The site of injury varied with the kind of trauma that caused it. (See Table 1.)

Multiple Injuries

Trauma to the liver, colon, diaphragm, stomach and small intestine was frequently associated with other injuries. More than one abdominal site was involved in about one fourth of the cases.

Roentgen Findings

Radiologic diagnosis in abdominal trauma is difficult. Roentgen findings were studied under four headings: Fractures, reactive ileus, roentgen opaque foreign bodies, and last, but most important, findings associated with the escape of gas, blood, fluids or contrast media from normal locations.

¶ *Fractures.* The presence of fractures was a valuable lead to the site of internal trauma. Anteroposterior and oblique views were made for rib fractures, but these fractures were easily overlooked. Anteroposterior views were made for fractures of transverse processes and the pelvis.

¶ *Reactive ileus.* Dilated gas-filled portions of the gastrointestinal tract roughly localized the sites of injury. Anteroposterior views recumbent, erect and in the lateral decubitus position were used for this purpose.

¶ *Foreign bodies.* Correlation of the position of roentgen-opaque foreign bodies with the site of the wound of entrance permitted an intelligent guess regarding the possible sites of injury. Anteroposterior and lateral views were a minimum requirement.

¶ *Escape of gas, blood, fluids or contrast media.* The findings produced by such phenomena were the most important in pointing to the site of trauma.

Escaped Gas

It was observed that the gaseous content of a hollow viscus usually escaped into the peritoneal cavity, less frequently into the retroperitoneal space. The stomach, colon and small intestine were the usual sources of traumatic pneumoperitoneum. Penetrating trauma to the abdominal wall resulted in pneumoperitoneum, even in the absence of perforation of a hollow viscus. Retroperitoneal emphysema resulted from perforation of a hollow viscus on its posterior mesenteric attachment or from the rupture of a retroperitoneal portion of intestinal tract such as the second part of the duodenum. Rupture of the second part of the duodenum resulted in either pneumoperitoneum or retroperitoneal emphysema. These findings were often absent on initial films (as was previously reported by Jacobson and Carter⁵) but sometimes appeared on films made later.

Retroperitoneal emphysema was demonstrated with a simple anteroposterior projection of the abdomen. Pneumoperitoneum was demonstrated on such films by visualization of the walls of the intestinal tract. That this could be done was due to the contrast between the air in the lumen and that in the peritoneal cavity. The condition was often difficult to detect and one or more of the following projections were usually required to demonstrate the pneumoperitoneum: An anteroposterior or posteroanterior film of the chest with the trunk erect; an anteroposterior or posteroanterior film of the abdomen in erect position, showing the diaphragm; anteroposterior or posteroanterior projections in the right and left lateral decubitus positions; a translateral view particularly in Fowler's position (i.e., the patient lies recumbent with the pelvis lower than the upper abdomen, the central ray being horizontal).

Escape of Blood or Fluid

Escaping blood or fluid caused abnormal densities, obscured normal shadows or displaced or encroached on normal structures.

Abnormal densities

The hemorrhage was sometimes confined by the capsule of an organ and was manifested as a localized bulge or as a general enlargement of the organ in question (spleen, kidney, liver). Intramural hematomata of the wall of the gastrointestinal tract (as reported by Felson²) may cause a filling defect in the barium filled duodenum.

The hemorrhage was sometimes confined by natural barriers, as by the splenic fossa or the retroperitoneal area (particularly in injuries to the spleen and kidney). Radiologically it appeared at times as a diffuse density in the involved region. Perisplenic hematomata gave the appearance of a grossly enlarged organ with a fairly sharp outline.

Hemoperitoneum was present particularly after splenic or hepatic trauma. Radiologically it caused a diffuse density, displaced the gas filled intestine from the flanks and separated the bowel loops. We found it difficult to consistently recognize even fairly large (500-1,500 cc.) accumulations of blood in the peritoneal cavity. Shifting densities, when both lateral decubitus films are made, helped occasionally. Traumatic pneumoperitoneum made it possible to recognize smaller accumulations in the peritoneal cavity. Birsner¹ recommended artificial pneumoperitoneum to help in this regard.

Infiltration of the gastroligament by hemorrhage was said by Gershon-Cohen and co-workers⁴ to be the cause of increased serrations of the greater curvature of the stomach as radiographically observed. This finding was more frequent in patients

with traumatized spleens, but was present in a considerable number of apparently normal subjects.

The site of the visceral fracture has been recognized as an irregularity of the margin of an organ. Frimann-Dahl³ noted this roentgenographic abnormality in laceration of the liver. Birsner¹ said that pneumoperitoneum helped in the demonstration of such a defect.

Fluid-filled segments of the gastrointestinal tract produced confusing densities which sometimes simulated tumorous masses. Hematomata of the abdominal wall mimicked organ enlargement or encapsulated intra-abdominal or retroperitoneal hematomata.

Obliteration of outlines

A listing of the structures that may be obscured by escaped fluids and the site of the injury permitting the extravasation follows:

Psoas shadows—retroperitoneal, renal and splenic trauma.

Renal shadows—retroperitoneal, renal and splenic trauma.

Splenic shadow (which, according to Wyman,¹⁰ can be seen in only 58 per cent of normal subjects) is frequently obscured by perisplenic hematomata.

The liver margins may be obscured as a result of liver trauma, by retroperitoneal hematoma or general hemoperitoneum.

Properitoneal fat lines may be dimmed or obscured by hemorrhage or exudate in the region.

Displacements

Natural air contrast was usually relied upon to demonstrate displacement of the gastrointestinal tract. Artificial air contrast can be provided by pneumoperitoneum, by insufflation of the gastrointestinal tract or by presacral air injection. Barium studies may also be employed to outline the gastrointestinal tract (Lowman and Davis⁶). Arteriograms can be used to show vascular displacements. Such special studies were infrequently employed. Urinary tract displacements were shown by urograms, pyelograms and cystograms. Two views at right angles to each other were required for full appreciation of displacements in three dimensions. One or more of the following findings were found with hemorrhage into or about the following organs or regions:

Liver enlargements. Elevated right diaphragm, right pleural effusion; compression atelectasis of the right base, depression of the hepatic flexure and displacement of the stomach and duodenal bulb to the left.

Right retroperitoneal mass. Elevated right dia-

phragm, right pleural effusion, compression atelectasis of the right base, depression and anterior displacement of hepatic flexure may occur, the transverse colon may be elevated, the stomach, duodenal bulb and particularly the second portion of the duodenum may be displaced to the left, there may be scoliosis convexity toward the contralateral side, the kidney may be displaced superiorly, laterally, medially, inferiorly, or anteriorly depending on the location of the mass, and the ureter may show medial displacement.

Masses in splenic fossa. Left diaphragm may be elevated, and there may be left pleural effusion, left basilar compression atelectasis, displacement to the right and intrinsic pressure defect of the greater curvature of the stomach, depression of the splenic flexure of the colon and, rarely, inferior displacement of the kidney.

Masses in the left retroperitoneal area. Left diaphragmatic elevation, compression atelectasis of the left lung base, left pleural effusion, anterior displacement and extrinsic pressure defect of the gastric pars media, elevation of transverse colon and lateral displacement of the descending colon, medial displacement of the ureter and renal displacement, the direction depending on the location of the mass (anterior displacement should be looked for). Scoliosis with concavity toward the ipsilateral side may be noted.

Bladder. Elevation and narrowing of the bladder shadow to produce a tear-drop shape.

Contrast Studies

The following uses of contrast studies were made:

Bladder. Extravasation was demonstrated by cystograms. Urograms were generally less reliable. Oblique as well as anteroposterior views should be made, and it was noted that an anteroposterior view after voiding sometimes disclosed conditions otherwise not demonstrated.

Kidney. In some cases urograms demonstrated that urinary excretion was unilateral, or diminished or completely absent. Findings of displacement or compression of the pelvicalyceal structures, and sometimes extravasation of contrast substance outside the pelvicalyceal system were shown. In some cases urograms taken demonstrated such extravasation when it was not seen on the original films. Sometimes retrograde studies demonstrated extravasation not shown by urograms.

Arteriograms. These studies should be used in selected cases only. Some physicians might consider them to be indicated for patients whose general condition is stabilized and in whom serious injury such as a ruptured spleen is suspected but

not diagnosed by other means. Many surgeons would prefer exploration in these circumstances. Post-traumatic renal hypertension would appear to be another indication.⁷ The findings would include extravasations from the arterial tree, vascular displacements,⁸ vascular occlusions and avascular areas owing to thrombi, spasm or occlusion of arteries by extrinsic pressure.⁷

Department of Radiology, Harbor General Hospital, 1124 West Carson Street, Torrance (Woodruff).

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